quite large in the infant and decreases in size with age. Often, there is no discernible thymic tissue in older adults. The thymus produces lymphocytes, which move to other lymph tissues to help fight infection. The thymus plays a major role in immunity, especially in early life.

The Respiratory System

The respiratory system is associated with breathing, gas exchange, and the entrance of air into the body. The organs and structures in the respiratory system are divided into the upper and lower airways. The upper airway includes the mouth, nasal cavity, and oral cavity, and the lower airway includes the larynx, trachea, bronchi, bronchioles, and alveoli.

The Upper Airway

A human can breathe air into the body through either the nose, also called the nasal cavity or nasopharynx, or through the mouth, also called the oral cavity or oropharynx. The nasopharynx and oropharynx connect posteriorly to form a cavity called the pharynx.

The nasopharynx extends from the internal nares to the uvula (a small fleshy mass that hangs from the soft palate). The oropharynx extends from the uvula to the

Figure 5-112  The respiratory system. A. The upper and lower airway divisions of the respiratory system. The insert shows a higher magnification of the alveoli, where oxygen and carbon dioxide exchange occurs. B. A scanning electron micrograph of the alveoli, showing the rich capillary network surrounding them.
epiglottis, the thin plate of cartilage that closes over the glottic opening during swallowing. Inferiorly, the pharynx leads to the separate openings of the respiratory system (larynx) and the digestive system (esophagus).

The external openings of the nasopharynx are the external nares or nostrils. The interior nares comprise the posterior opening from the nasopharynx into the pharynx. The nasal septum separates the nasopharynx into two parts. The floor of the nasal cavity is the hard palate. The lateral walls of the nasopharynx contain three bony ridges, the conchae. Together, the conchae form a set of bony convolutions, called the turbinates, which help to maintain laminar (smooth) airflow. Below each turbinate is a passageway called a meatus. Each meatus contains the drainage opening from the sinus and the nasolacrimal ducts (the ducts that drain tears from the lacrimal sac).

The Lower Airway

The beginning of the lower airway, the larynx, consists of several sections of cartilage held together by ligaments. The larynx includes two pairs of ligaments that form the vocal cords. The superior portion of the vocal cords forms the vestibular folds, or false vocal cords; the inferior portion forms the true vocal cords. Vibration of the true vocal cords results in production of sounds and speech. The true vocal cords plus the opening between them is called the glottis.

The trachea is immediately inferior to the larynx and is approximately 4” long in most adults. The trachea is a tube made up of cartilage and other connective tissue and conveys air to and from the lungs. The cartilage forms the anterior and lateral sides of the trachea, providing both protection and an open passageway for air. The esophagus is immediately posterior to the cartilage-free posterior wall of the trachea. At the level of the fifth thoracic vertebra, the trachea branches into the right and left mainstem bronchi at the carina, a projection of the lowest portion of the tracheal cartilage.

Beyond the carina, air enters the lungs through the mainstem bronchi. The point of entry for the bronchi, vessels, and nerves into each lung is called the hilum. The mainstem bronchi divide into the secondary bronchi, each one going to a separate lobe of the lung (see Figure 5-114).

Secondary bronchi branch into tertiary bronchi, which continue to branch several times. After several generations of successive branching, bronchioles, very small subdivisions of the bronchi, are formed. Respiratory bronchioles develop from the final branching of the bronchiole. Each respiratory bronchiole divides to form alveolar ducts. Each alveolar duct ends in clusters known as alveoli, tiny sacs of lung tissue in which gas exchange takes place. The lung contains approximately 300 million alveoli; each alveolus is about 0.33 mm in diameter. Capillaries cover the alveoli. The alveolo-capillary membrane lies between the alveolus and the capillary and is very thin, consisting of only one cell layer. Respiratory exchange between the lung and blood vessels occurs in the alveoli at the alveolo-capillary membrane.

The lungs are the primary organs of breathing. The right lung contains three lobes (the upper, middle, and lower lobes); the left lung contains only two (the upper and lower lobes). In the left lung, a portion known as the lingula forms the equivalent of the middle lobe in the right lung. The lungs are surrounded by a mem-
brane of connective tissue known as **pleura**. Another pleural membrane lines the inner borders of the rib cage, or **pleural cavity**.

The pleural membrane that covers the lungs is referred to as the **visceral pleura**, and the pleural membrane that lines the pleural cavity is the **parietal pleura**. A potential space known as the **pleural space** exists between the visceral and parietal pleura. Normally, the two membranes are close together and a space does not exist. Both layers of pleura work together to help maintain normal expansion and contraction of the lung. Under certain disease conditions or following trauma, fluid and/or air may accumulate in the pleural space, resulting in hemothorax (a collection of blood in the pleural space) or hemopneumothorax (a collection of blood and air in the pleural space), potentially causing respiratory problems.

The lungs receive blood in two ways. Deoxygenated blood flows from the right ventricle via the pulmonary arteries. This blood flows through pulmonary capillaries, is reoxygenated at the alveoli, and then returns to the heart via the pulmonary veins.
In addition, bronchial arteries branch off of the thoracic aorta and supply the lung tissues themselves with blood. Deoxygenated blood returns to the heart via the bronchial veins and the azygos system. Peripherally in the lungs, venous blood from the bronchi enters the pulmonary veins, returning with oxygenated blood from the alveoli.

**Respiratory Physiology**

The primary function of the respiratory system is to exchange gases at the alveolocapillary membrane. Oxygen is essential for the body to function. The amount of oxygen in inspired air is approximately 21%. The primary waste product of metabolism is carbon dioxide, which is carried in the blood to the lungs. **Ventilation** is the process of moving air in and out of the lungs.

**Pulmonary function tests** assess volumes of air that move into and out of the lungs. Usually, measurement involves the use of a **spirometer**, a device that records the amount and rate of air that is breathed in and out over a specific period of time. Some commonly measured parameters include **tidal volume** (the volume of air inspired during normal inspiration), **residual volume** (the volume of air remaining in the respiratory passages and lungs after a forceful expiration), **vital capacity** (the amount of air moved in and out of the lungs with maximum inspiration and expiration), and **forced expiratory vital capacity (FEVI)** (the volume of air exhaled from the lung following a forceful exhalation).

At the alveolocapillary exchange surface, the alveolus and the red blood cells are located very close together. Diffusion is the process by which a gas dissolves in a liquid. Through the process of diffusion, the gases move from a higher concentration to a lower concentration. Therefore, oxygen moves across the membrane into the capillaries where it attaches to the hemoglobin. Likewise, carbon dioxide moves into the alveoli where the concentration is lower. Oxygenated blood enters the left side of the heart and is pumped to the tissues. Oxygen is “offloaded” from the red blood cells to the tissues as carbon dioxide and waste products from the tissues are “loaded” into the bloodstream. Venous blood returns to the right side of the heart and the pul-
monary capillary bed (via the pulmonary arteries). The carbon dioxide diffuses into the alveoli and is released into the atmosphere as the individual exhales.

Because there are so many alveoli, a fairly large surface area exists for respiratory exchange to occur in the context of the relatively limited size of the thoracic cavity. The total surface area created around the alveoli is more than 85 m² (Figure 5-117). This is significantly more than would exist if each lung consisted of only a single sphere, like a large balloon. In that case, the surface area would be only 0.01 m² (1 m = 39.37°).

Respiration is controlled by the brain. The respiratory center is located in the medulla oblongata. A complicated interaction of signals provides feedback to the respiratory center, allowing it to continuously control respiration. The main respiratory stimulus is accumulation of carbon dioxide in the blood. Typically, this is measured as the PaCO₂ on the arterial blood gases. Increases in the PaCO₂ result in decreased pH levels in the respiratory center, which triggers an increase in ventilation. Decreases in the PaCO₂ result in increased pH levels in the respiratory center and a decrease in ventilation. Low blood oxygen levels also stimulate breathing, but normally have much less of an effect than does the PaCO₂.

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**EMT-I Tips**

Individuals with reversible restrictive lower airway disease, such as asthma, or progressive, irreversible airway disease resulting from emphysema (destruction of alveolar walls), black lung disease (consistent inhalation of coal dust), asbestosis (inhalation of asbestos particles), or chronic bronchitis (excess mucus production that blocks the airway) demonstrate typical abnormalities on pulmonary function testing. Residual volume often is increased, and the forced expiratory volume in the first second is decreased. Abnormalities of these parameters indicate chronic obstructive lung disease. Often, the technician measures lung function before and following administration of a bronchodilator, medication that is designed to decrease airway resistance and thereby improve lung function. Individuals with black lung disease, asbestosis, or other forms of lung scarring may demonstrate a significant decrease in the vital capacity, indicating restrictive lung disease.
Chronic obstructive pulmonary disease (COPD) is a progressive, irreversible disease of the airway marked by decreased inspiratory and expiratory capacity of the lungs. COPD may result from chronic bronchitis (excess mucus production) or emphysema (lung tissue damage with loss of elastic recoil of the lungs). Patients with COPD usually have a combination of both problems and generally function at a certain baseline level until an event occurs that causes decompensation and an acute COPD episode (or acute exacerbation). As with asthma, inflammation recently has been shown to play a significant role in COPD.

Chronic bronchitis results from overgrowth of the airway mucous glands and excess secretion of mucus, which blocks the airway. Patients have a chronic productive cough. Emphysema results from destruction of the alveolar walls, which creates resistance to expiratory airflow. The major cause of COPD is cigarette smoking. Industrial inhalants (such as asbestos and coal dust), air pollution, and tuberculosis can also lead to COPD. The patient in an acute COPD episode will complain of shortness of breath with gradually increasing symptoms over a period of days.

Arterial blood gas tests measure the partial pressure of oxygen (Pao₂) and the partial pressure of carbon dioxide (Paco₂) in the blood, as well as the pH, (the degree of acidity or alkalinity). Deviations from normal values occur in many different disease states. Essentially, Paco₂ acts as “respiratory acid.” Changes in the Paco₂ value rapidly change the pH levels, either making it more basic (increased) or more acidic (decreased). Changes in the Paco₂ can be the result of diseases such as asthma, COPD exacerbation, or drug overdose or secondary to a change in the blood pH because of a metabolic problem. A decrease in the pH of the arterial blood that is caused by an elevation in the Paco₂ is called a primary respiratory acidosis, whereas an increase in the pH of the blood that is caused by excessive exhalation of CO₂ is called a primary respiratory alkalosis. Conversely, changes in the Paco₂ that occur in response to primary metabolic problems (alkalosis or acidosis) are called compensatory changes.
During inhalation, the diaphragm contracts and negative pressure is created in the chest cavity. The negative pressure results in air being “sucked” in, and the air fills the lungs. Air is expired when the lung tissue, characterized by elasticity, collapses. Exhalation is a passive process that does not normally require effort.

We also have a “backup system” to control respiration called the hypoxic drive. When oxygen levels fall, this system will also stimulate breathing. There are areas in the brain, the walls of the aorta, and the carotid arteries that act as oxygen sensors. Minimal levels of oxygen in the arterial blood easily satisfy these sensors. Therefore, our backup system, the hypoxic drive, is much less sensitive and less powerful than the carbon dioxide sensors in the brain stem.

The Digestive System

The digestive system is composed of the gastrointestinal tract (stomach and intestines), mouth, salivary glands, pharynx, esophagus, liver, gallbladder, pancreas, rectum, and anus. The function of this system is digestion: the processing of food that nourishes the individual cells of the body.

How Digestion Works

Digestion of food, from the time it is taken into the mouth until essential compounds are extracted and delivered by the circulatory system to nourish all of the cells in the body, is a complicated chemical process. In succession, different secretions, primarily enzymes, are added to the food by the salivary glands, the stomach, the liver, the pancreas, and the small intestine to convert the food into basic sugars, fatty acids, and amino acids. These basic products of digestion are carried across the wall of the intestine and transported through the portal vein to the liver. In the liver, the products are processed further and then stored or transported to the heart through veins draining the liver. The heart then pumps the blood with these nutrients throughout the arteries and then to the capillaries, where the nutrients pass through the capillary walls to nourish the body’s individual cells.
In normal routine activity, without any food or fluid ingestion at all, between 8 to 10 L of fluid is secreted daily into the gastrointestinal tract. This fluid comes from the salivary glands, stomach, liver, pancreas, and small intestine. In a normal adult, about 7% of the body weight is delivered as fluid daily to the gastrointestinal tract. If significant vomiting or diarrhea occurs for more than 2 or 3 days, the patient will lose a very substantial portion of body composition and become severely ill.

**Anatomy of the Digestive System**

**Mouth**

The mouth consists of the lips, cheeks, gums, teeth, and tongue. A mucous membrane lines the mouth. The hard and soft palates form the roof of the mouth. The hard palate is a bony plate lying anteriorly; the soft palate is a fold of mucous membrane and muscle that extends posteriorly from the hard palate into the throat. The soft palate is designed to hold food that is being chewed within the mouth and to help initiate swallowing.

**Salivary Glands**

There are two salivary glands located under the tongue, one on each side of the lower jaw, and one inside each cheek. They produce nearly 1.5 L of saliva daily. Saliva is approximately 98% water. The remaining 2% is composed of mucus, salts, and organic compounds. Saliva serves as a binder for the chewed food that is being swallowed and as a lubricant within the mouth.

**Oropharynx**

The oropharynx is a tubular structure about 5” long that extends vertically from the back of the mouth to the esophagus and trachea. An automatic movement of the pharynx during swallowing lifts the larynx to permit the epiglottis to close over it so that liquids and solids are moved into the esophagus and away from the trachea.

**Esophagus**

The esophagus is a collapsible tube about 10” long that extends from the end of the pharynx to the stomach and lies just anterior to the spinal column in the chest. Contraction of the muscle in the wall of the esophagus propel food through it to the stomach. Liquids will pass with very little assistance.

**Stomach**

The stomach is located in the left upper quadrant of the abdominal cavity, largely protected by the lower left ribs. Muscular contractions in the wall of the stomach and gastric juice, which contains much mucus, convert ingested food to a thoroughly mixed semi-solid mass. The stomach produces approximately 1.5 L of gastric juice daily for this process. The principal function of the stomach is to receive food in large quantities intermittently, store it, and provide for its movement into the small bowel in regular, small amounts. In 1 to 3 hours, the semisolid food mass derived from one meal is propelled by muscular contraction into the duodenum, the first part of the small intestine.

**Pancreas**

The pancreas, a flat, solid organ, lies below and behind the liver and stomach and behind the peritoneum. It is firmly fixed in position, deep within the abdomen, and is not easily damaged. It contains two kinds of glands. One set of glands secretes nearly 2 L of pancreatic juice daily. This juice contains many enzymes that aid in the digestion of fat, starch, and protein. Pancreatic juice flows directly into the duodenum through the pancreatic ducts. The other gland is the islets of Langerhans, which produces insulin. Insulin regulates the amount of glucose in the blood.

**Liver**

The liver is a large, solid organ that takes up most of the area immediately beneath the diaphragm in the right upper quadrant. It is the largest solid organ in the abdomen and has several functions. Poisonous substances produced by digestion are brought to the liver and rendered harmless. Factors that are necessary for blood clotting and for the production of normal plasma are formed here. Between 0.5 and 1 L of bile is made by the liver daily to assist in the normal digestion of fat. The liver is the principal organ for the storage of sugar or starch for immediate use by the body for energy. It also produces many of the factors that aid in the proper regulation of immune responses. Anatomically, the liver is a large mass of blood vessels and cells, packed tightly together. It is fragile and, because of its size, relatively easily injured. Blood flow in the liver is high, because all of the blood that is pumped to the gastrointestinal tract passes into the liver, through the portal vein, before it returns to the heart. In addition, the liver has a generous arterial blood supply of its own. Ordinarily, approximately 25% of the cardiac output of blood (1.5 L) passes through the liver each minute.
Bile Ducts

The liver is connected to the intestine by the bile ducts. The gallbladder is an outpouching from the bile ducts that serves as a reservoir and concentrating organ for bile produced in the liver. Together, the bile ducts and gallbladder form the biliary system. The gallbladder discharges stored and concentrated bile into the duodenum through the common bile duct. The presence of food in the duodenum triggers a contraction of the gallbladder to empty it. The gallbladder usually contains about 60 to 90 mL of bile.

Small Intestine

The small intestine is the major hollow organ of the abdomen. The cells lining the small intestine produce enzymes and mucus to aid in digestion. Enzymes from the pancreas and the small intestine carry out the final processes of digestion. More than 90% of the products of digestion (amino acids, fatty acids, and simple sugars), together with water, ingested vitamins, and minerals are absorbed across the wall of the lower end of the small intestine into veins to be transported to the liver. The small intestine is composed of the duodenum, the jejunum, and the ileum. The duodenum, which is about 12” long, is the part of the small intestine that receives food from the stomach. Here, food is mixed with secretions from the pancreas and liver for further digestion. Bile, produced by the liver and stored in the gallbladder, is emptied as needed into the duodenum. It is greenish black, but through changes during digestion, it gives feces its typical brown color. Its major function is in the digestion of fat. The jejunum and ileum together measure more than 20’ on average to make up the rest of the small intestine.

Large Intestine

The large intestine, another major hollow organ, consists of the cecum, the colon, and the rectum. About 5’ long, it encircles the outer border of the abdomen around the small bowel. The major function of the colon, the portion of the large intestine that extends from the cecum to the rectum, is to absorb the final 5% to 10% of digested food and water from the intestine to form solid stool, which is stored in the rectum and passed out of the body through the anus.

Appendix

The appendix is a tube 3” to 4” long that opens into the cecum (the first part of the large intestine) in the right lower quadrant of the abdomen. It may easily become obstructed and, as a result, inflamed and infected. Appendicitis, which is the term for this inflammation, is one of the major causes of severe abdominal distress. The appendix has no known function.

Rectum

The lowermost end of the colon is the rectum. It is a large, hollow organ that is adapted to store quantities of feces until it is expelled. At its terminal end is the anus, a 2” canal lined with skin. The rectum and anus are supplied with a complex series of circular muscles called sphincters that control, both voluntarily and automatically, the escape of liquids, gases, and solids from the digestive tract.

The Urinary System

The urinary system controls the discharge of certain waste materials filtered from the blood by the kidneys. In the urinary system, the kidneys are solid organs; the ureters, bladder, and urethra are hollow organs (Figure 5-119). Ordinarily, we consider the urinary and genital systems together, because they share many organs.

The body has two kidneys that lie on the posterior muscular wall of the abdomen behind the peritoneum in the retroperitoneal space. These organs rid the blood of toxic waste products and control its balance of water and salt. Blood flow in the kidneys is high. Nearly 20% of the output of blood from the heart passes through the kidneys each minute. Large vessels attach the kidneys directly to the aorta and the inferior vena cava. Waste products and water are constantly filtered from the blood to form urine. The kidneys continuously concentrate this filtered urine by reabsorbing the water as it passes through a system of specialized tubes within them. The tubes finally unite to form the renal pelvis, a cone-shaped collecting area that connects the ureter and the kidney. Normally, each kidney drains its urine into one ureter through which the urine passes to the bladder.

A ureter passes from the renal pelvis of each kidney along the surface of the posterior abdominal wall behind the peritoneum to drain into the urinary bladder. The ureters are small (0.2” in diameter), hollow, muscular tubes. Peristalsis, a wave-like contraction of smooth muscle, occurs in these tubes to move the urine to the bladder.

The urinary bladder is located immediately behind the pubic symphysis in the pelvic cavity and is composed of smooth muscle with a specialized lining membrane. The two ureters enter posteriorly at its base on
either side. The bladder empties to the outside of the body through the urethra. In the male, the urethra passes from the anterior base of the bladder through the penis. In the female, the urethra opens at the front of the vagina. The normal adult forms 1.5 to 2 L of urine every day. This waste is extracted and concentrated from the 1,500 L of blood that circulate through the kidneys daily.

### The Genital System

The genital system controls the reproductive processes by which life is created. The male genitalia, except for the prostate gland and the seminal vesicles, lie outside the pelvic cavity. The female genitalia are contained entirely within the pelvis. The male and female reproductive organs have certain similarities and, of course, basic differences. They allow the production of sperm and egg cells and appropriate hormones and the act of sexual intercourse and reproduction.

### The Male Reproductive System and Organs

The male reproductive system consists of the testicles, vasa deferentia, seminal vesicles, prostate gland, urethra, and penis (Figure 5-120). Each testicle contains specialized cells and ducts; some of these produce male hormones, and others develop sperm. The hormones are absorbed directly into the bloodstream from the testicles. The vasa deferentia (or vas deferens) are ducts that travel from the testicles up beneath the skin of the abdominal wall for a short distance. They then pass through an opening into the abdominal cavity and into the prostate gland to connect with the urethra. The vasa deferentia carry the sperm from the testicles to the urethra. The seminal vesicles are small storage sacs for sperm and seminal fluid. The vesicles also empty into the urethra, at the prostate.

Semen, also called seminal fluid, contains sperm cells that are carried up each vas from each testicle to be mixed with fluid from the seminal vesicles and prostate gland. The prostate gland surrounds the urethra where it emerges from the urinary bladder. Fluids from the prostate gland and from the seminal vesicles mix during sexual intercourse. During intercourse, special mechanisms in the nervous system prevent the passage of urine into the urethra. Only seminal fluid, prostatic fluid, and sperm pass from the penis into the vagina during ejaculation.

The penis contains a special type of tissue called erectile tissue. This specialized tissue is largely vascular and, when filled with blood, causes the penis to distend into a state of erection. As the vessels fill under pressure from the circulatory system, the penis becomes a large, rigid organ that can enter the vagina. Certain spinal injuries and some diseases can cause a painful continuous erection called priapism.

### The Female Reproductive System and Organs

The female reproductive organs include the ovaries, fallopian tubes, uterus, cervix, and vagina (Figure 5-121). The ovaries, like the testicles, produce sex hormones and
Figure 5-120  The male reproductive system consists of the testicles, vasa deferentia, seminal vesicles, prostate gland, urethra, and penis.

Figure 5-121  The female reproductive system consists of the ovaries, fallopian tubes, uterus, cervix, and vagina.
specialized cells for reproduction. The female sex hormones are absorbed directly into the bloodstream. A specialized ovum, or egg cell, is produced regularly during the adult female’s reproductive years. The ovaries release a mature egg approximately every 28 days. This egg travels through the fallopian tubes to the uterus. The fallopian tubes connect with the uterus and carry the ovum into the cavity of this organ. The uterus is pear-shaped and hollow, with muscular walls. The narrow opening from the uterus to the vagina is the cervix. The vagina (birth canal) is a muscular distensible tube that connects the uterus with the vulva (the external female genitalia). The vagina receives the penis during sexual intercourse, when semen is deposited in it. The sperm in the semen may pass into the uterus and fertilize an egg, causing pregnancy. Should the pregnancy come to completion at the end of nine months, the baby will pass through the vagina and be born. The vagina also channels the menstrual flow from the uterus out of the body.

Fluids and Electrolytes

Body Fluid Balance

The total body water content of the average adult ranges from 50% to 70% of total body weight, depending on age and sex. A newborn’s total body water content may be as high as 75% to 80% of total body weight.

Body fluid is divided into two main compartments: intracellular fluid and extracellular fluid. Intracellular fluid (ICF) exists within individual cells and equals approximately 40% to 45% of total body weight. The intracellular fluid makes up approximately 75% of all body fluid. Extracellular fluid (ECF) exists outside of the cell membranes. It equals approximately 15% to 20% of the total body weight, or 25% of all body fluid. Extracellular fluid is further divided into intravascular fluid and interstitial fluid. Intravascular fluid (plasma), the fluid portion of blood, is found within the blood vessels and accounts for approximately 4.5% of total body weight. Interstitial fluid is located outside of the blood vessels, in the spaces between the body’s cells. It accounts for approximately 10.5% of total body weight. There is a delicate balance among the various fluid compartments of the body that is essential to maintain homeostasis.

If fluid is lost from anywhere in the body, there can be serious ramifications because this disturbs the balance among various fluid compartments (homeostasis). The result can be shock. Under normal conditions, the total volume of water in the body and its distribution in the body compartments remain relatively constant, even though there are fluctuations in the amount of water that enters and is excreted from the body each day. Fluid balance is the process of maintaining homeostasis through equal intake (water taken into the body) and output (water excreted from the body) of fluids.

There are mechanisms in the body that maintain the balance between what is taken in and what is excreted. For example, when the fluid volume drops, the pituitary gland secretes antidiuretic hormone (ADH). ADH causes the kidney tubules to reabsorb more water into the blood and excrete less urine, allowing fluid volume in the body to build up. Thirst also regulates fluid intake. The sensation of thirst occurs when body fluids become decreased, stimulating an individual to take in more fluids. Conversely, when too many fluids enter the body, thirst decreases, the kidneys are activated, and more urine is excreted, eliminating the excess fluid.

It is important to maintain the proper balance of fluids and electrolytes within the body, because this is necessary for life. An individual’s body can become depleted of fluids and electrolytes for several reasons, including severe burns or dehydration. The body can maintain fluid balance by shifting water from one compartment to another. Water moves in response to osmotic forces as well as hormonal stimuli such as ADH. For a patient whose fluids or electrolytes are depleted, rapid restoration of fluid balance may mean the difference between life and death.

<table>
<thead>
<tr>
<th>TABLE 5-4 Major Mechanisms for Fluid Homeostasis</th>
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<tbody>
<tr>
<td>Antidiuretic hormone (ADH)</td>
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<td>Thirst</td>
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<tr>
<td>Kidneys</td>
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<td>Water shifts</td>
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Acid-Base Balance

An acid is a substance that increases the concentration of hydrogen ions in a water solution. A base is a substance that decreases the concentration of hydrogen ions.

Whether the blood or body fluid is acidic, basic, or neutral depends on the concentration of dissolved hydrogen (H⁺). Hydrogen is an acid. This means that the higher the concentration, the more acidic the blood will be; conversely, the lower the H⁺ concentration, the more basic (less acidic) the blood will be. Normal homeostatic functions keep the concentration of H⁺ within a fairly narrow range.

The most common expression of acidity is pH, which is a value calculated from H⁺ concentration:

\[ \text{pH} = \text{concentration of hydrogen ions} \]

Therefore, the lower the hydrogen ion concentration, the greater the pH (more basic) will be, and the higher the hydrogen ion concentration, the lower the pH (more acidic) will be. pH ranges from 0 (most acidic) to 14 (most basic), with 7.0 being neutral. (The pH of pure water, which is considered neutral, is 7.0.) The pH of the human body is normally slightly basic, or alkaline, ranging approximately 7.35 to 7.45. When pH is higher than this, the blood is too basic, or alkalotic. When pH is lower, the blood is too acidic, or acidotic (Figure 5-123).
Therefore, buffer systems act as fast defenses for acid-base changes, providing almost immediate protection against changes in the hydrogen ion concentration of the extracellular fluid. The generic reaction is expressed as follows:

$$\text{H}^+ + \text{Buffer} \leftrightarrow \text{H-Buffer}$$

Free H\(^+\) (acid) binds with the buffer to form a weak acid (H-Buffer). This reaction can shift to the right or left depending on the hydrogen ion concentration. When the H\(^+\) concentration increases and buffer is available, the reaction is forced to the right and more H-Buffer is formed. When the H\(^+\) concentration decreases, the reaction shifts toward the left, and H\(^+\) disassociates from the buffer, leaving H\(^+\) and buffer.

The respiratory system and the renal system work in conjunction with the bicarbonate buffer to maintain homeostasis. The fastest way the body can get rid of excess acid is through the respiratory system. Excess acid can be expelled as CO\(_2\) from the lungs. Conversely, slowing respirations will increase CO\(_2\) in alkalotic states. The renal system regulates pH by filtering out more hydrogen and retaining bicarbonate in acidotic states, and doing just the reverse in alkalotic states. This will be discussed in more detail in upcoming chapters.

**You are the Provider**

1. How does each body system respond when another body system is damaged from illness or injury?

   Maintenance of the internal environment of the cell is regulated by elaborate systems of checks and balances. As systems in the body become imbalanced and begin to shift, feedback systems create an appropriate response to return the internal environment to normal. This normally balanced condition is referred to as homeostasis, or the resistance to change.

2. What is anatomy, physiology, and pathophysiology?

   Anatomy refers to the study of the structure of an organism and its parts. Gross anatomy includes body parts that are generally visible to the naked eye—the bones, the muscles, and the organs. Microscopic anatomy involves components of the body that are small, often visible only through a microscope. Physiology examines the body functions of the living organism. Pathophysiology is the study of the body functions of a living organism in an abnormal state, such as a disease.

**Summary**

Figure 5-123 The pH scale.
3. How can knowledge of medical terminology help the EMT-I care for this patient?

EMTs must be familiar with the language of topographic anatomy. By using the proper medical terms, you will be able to communicate correct information with the least possible confusion to other members of the health care team.

4. How can knowledge of anatomy and physiology help the EMT-I care for patients?

Familiarity with the structures and function of the body’s systems will allow you to better assess a patient as well as predict potential complications resulting from occult injuries (those not visible to the eye).

5. What is the function of the skeletal system?

The skeleton gives us our recognizable human form and protects our vital internal organs.

6. What is the musculoskeletal system designed to do?

The skeleton is designed to allow motion of the body. It involves coordinated function of the muscles and the skeleton.

7. What is the most common method used to describe the abdomen?

The simplest and most common method of describing the portions of the abdomen is by quadrants, the four equal areas formed by two imaginary lines that intersect at right angles at the umbilicus. On the anterior abdominal wall, the quadrants thus formed are the right upper, right lower, left upper, and left lower. The terms “right quadrant” and “left quadrant” refer to the patient’s right and left as you face them, not to your right and left sides.

8. Why is it important for the EMT-I to use these designations?

Pain or injury in a given quadrant usually arises from or involves the organs that lie in that quadrant. This simple means of designation will allow you to identify injured or diseased organs that require emergency attention.

9. What are the bones of the lower extremity?

The lower extremity includes the hip, thigh, knee, leg, ankle, foot, and toes.

10. What are the common causes of hip dislocations that the EMT-I should be aware of?

Dislocations of the hip joint commonly occur from a fall or during a motor vehicle collision in which the knee impacts the dashboard. The force of the impact is transmitted posteriorly to the hip, most commonly resulting in posterior dislocation.

11. What is the function of the medulla in the brain?

The medulla serves as a conduction pathway for both ascending and descending nerve tracts. It also coordinates heart rate, blood vessel diameter, breathing, swallowing, vomiting, coughing, and sneezing. The pons and medullary respiratory center are responsible for all respiratory movements.

12. How does the body respond when a patient loses blood?

When a patient loses a small amount of blood, the arteries, veins, and heart automatically adjust to the smaller new volume. The adjustment occurs in an effort to maintain adequate pressure throughout the circulatory system and thereby maintain circulation for every organ. The adjustment occurs very rapidly after the loss, usually within minutes. Specifically, the vessels constrict to provide a smaller bed for the reduced volume of blood to fill. And the heart pumps more rapidly to circulate the remaining blood more efficiently.

13. Body fluid is divided into two main compartments. What are they and where are they found?

Body fluid is divided into two main compartments: intracellular fluid and extracellular fluid. Intracellular fluid (ICF) is found within individual cells and equals approximately 40% to 45% of total body weight. The intracellular fluid makes up approximately 75% of all body fluid. Extracellular fluid (ECF) is the fluid found outside of the cell membranes. It equals approximately 15% to 20% of the total body weight, or 25% of all body fluid. Extracellular fluid is further divided into intravascular fluid and interstitial fluid. Intravascular fluid (plasma), the fluid portion of blood, is noncellular and is found within the blood vessels. It equals approximately 4.5% of total body weight. Interstitial fluid is the fluid located outside of the blood vessels, in the spaces between the body’s cells. It comprises approximately 10.5% of total body weight. There is a delicate balance among the various fluid compartments of the body that is essential in maintenance of homeostasis.
Ready for Review

To do your work as an EMT-I, you must have a working knowledge of human anatomy so that you can communicate with hospital personnel and other health care providers.

You must be able to identify superficial landmarks of the body and know what lies underneath the skin so that you can perform an accurate assessment. Hospital personnel will use these terms to ask you questions about a patient; therefore, it is critical for the well-being of your patient that you learn them and can use them correctly.

You must also have an understanding of physiology. Each body system works together to maintain homeostasis of the entire organism. Disruption in any system can lead to illness or even death. Knowledge of body systems and how they work will allow you to better assess and treat your patient.

Vital Vocabulary

**abdomen**  The body cavity that contains the major organs of digestion and excretion.

**abducens nerve**  The cranial nerve (VI) that supplies the lateral rectus muscle of the eyeball (lateral movement).

**abduction**  Motion of a limb away from the midline.

**acetabulum**  The depression on the lateral pelvis where its three component bones join, in which the femoral head fits snugly.

**acetylcholine**  A neurotransmitter secreted by the autonomic nervous system.

**acetylcholinesterase**  An enzyme that rapidly destroys acetylcholine once it has reached the target tissue.

**acid**  A substance that increases the concentration of hydrogen ions in a water solution.

**acidotic**  Blood that is too acidic.

**acromioclavicular (AC) joint**  The point at which the clavicle attaches to the acromion process.

**acromioclavicular (AC) separation**  One or more torn ligaments in the AC joint, resulting in a separated shoulder.

**acromion process**  The tip of the shoulder and the site of attachment for both the clavicle and various shoulder muscles.

**action potential**  A change in electrical potential that occurs when a cell or tissue has been activated by a stimulus.

**Adam’s apple**  The firm prominence in the upper part of the larynx formed by the thyroid cartilage. It is more prominent in men than in women.

**adduction**  Motion of a limb toward the midline.

**adenosine triphosphate (ATP)**  The major source of energy for all chemical reactions of the body.

**adipose tissue**  A type of connective tissue that contains large amounts of fat.

**adrenal cortex**  The outer layer of the adrenal gland; it produces hormones that are important in regulating the water and salt balance of the body.

**adrenal glands**  Glands located on top of each kidney that produce and secrete certain sex hormones, as well as other hormones that are vital to maintaining the body’s water and salt balance; also called suprarenal glands.

**adrenaline**  Hormone produced by the adrenal glands that mediates the “fight-or-flight” response of the sympathetic nervous system; also called epinephrine.

**adrenergic**  Description of a neuron that secretes the neurotransmitter norepinephrine.

**adrenergic receptor**  A receptor stimulated by the neurotransmitter norepinephrine.

**adrenocorticotropic hormone (ACTH)**  One of several molecules derived from a common precursor, proopiomelanocortin, that is essential for development of the cortex of the adrenal gland and its secretion of corticosteroids.

**aerobic metabolism**  A biochemical process that occurs in the presence of oxygen and results in the production of energy in the form of ATP; also called cellular respiration.
afferent nerves  Nerves that carry impulses from the body to the brain and provide input to the brain about sensations; also called sensory nerves.

afterload  The pressure in the aorta against which the left ventricle must pump blood.

agranulocytes  Leukocytes that lack granules.

aldosterone  A steroid hormone produced by the adrenal glands that increases the rate of sodium and water resorption from the distal tubules back into the blood.

alkalotic  Blood that is too basic.

alpha cells  Cells located in the islets of Langerhans that secrete glucagon.

alpha effects  Stimulation of alpha receptors that results in vasoconstriction.

alpha receptors  One of two adrenergic receptors classified into two structural and functional categories; are further subdivided into alpha1 and alpha2 receptors.

alveolar ducts  Ducts formed from division of the respiratory bronchioles in the lower airway; each duct ends in clusters known as alveoli.

alveoli  The air sacs of the lungs in which the exchange of oxygen and carbon dioxide takes place.

alveolocapillary membrane  The very thin membrane, consisting of only one cell layer, that lies between the alveolus and capillary, through which respiratory exchange between the alveolus and the blood vessels occurs.

anabolism  The productive component of metabolism associated with the build-up of energy stores and body tissues.

anaerobic metabolism  An alternate form of metabolism that occurs when oxygen levels are low and less energy is produced than during aerobic respiration; lactic acid is produced as a waste product during this process.

anatomic position  The position of reference in which the patient stands facing you, arms at the side, with the palms of the hands forward.

anatomy  The study of the structure of an organism and its parts.

androgens  Male sex hormones.

androstenedione  A steroid sex hormone secreted by the adrenal cortex, testes, and ovaries.

anemia  A decrease in the number of red blood cells, for any reason.

angle of Louis  A ridge on the sternum that lies at the level where the second rib is attached to the sternum; provides a constant and reliable bony landmark on the anterior chest wall.

anterior  The front surface of the body; the side facing you in the standard anatomic position.

anterior pituitary lobe (adenohypophysis)  One of the two portions of the pituitary gland; it produces hormones that are not neurohormones; also called the adenohypophysis.

anterior superior iliac spines  The bony prominences of the pelvis (ilium) at the front on each side of the lower abdomen just below the plane of the umbilicus.

antibodies  Proteins within plasma that react with antigens.

antidiuretic hormone (ADH)  A hormone released by the pituitary gland that causes the kidney to reabsorb more water into the blood and excrete less urine.

antigens  Substances on the surface of erythrocytes that are recognized by the immune system.

aorta  The principal artery leaving the left side of the heart and carrying freshly oxygenated blood to the body.

aortic arch  One of the three described portions of the aorta; the section of the aorta between the ascending and descending portions that gives rise to the right brachiocephalic (innominate), left common carotid, and left subclavian arteries.

aortic valve  The semilunar valve that regulates blood flow from the left ventricle to the aorta.

apex (plural: apices)  The tip or the topmost portion of a structure.

appendicular skeleton  The upper and lower extremities and the girdles that attach them to the axial skeleton.

appendix  A small tubular structure that is attached to the lower border of the cecum in the lower right quadrant of the abdomen.

appositional growth  The formation of new bone on the surface of a bone; one of the ways a bone grows.
arachnoid  The middle membrane of the three meninges that enclose the brain and spinal cord.
arteries  The blood vessels that carry blood away from the heart.
arteriole  The smallest branch of an artery leading to the vast network of capillaries.
asbestosis  A disease of the lungs caused by inhalation of asbestos particles.
ascenting aorta  The first of three portions of the aorta; originates from the left ventricle and gives rise to two branches, the right and left main coronary arteries.
ascenting fibers (afferent tracts)  Fibers that carry sensory information from the periphery to the brain; also called afferent tracts.
ascenting reticular activating system  Several structures located throughout the brainstem that are responsible for maintenance of consciousness.
asthma  A reversible restrictive lower airway disease.
atlanto-occipital joint  The location where the atlas articulates with the occipital condyles.
atlas  The first cervical vertebra (C1), which provides support for the head.
atrioventricular (AV) node  The site located in the right atrium adjacent to the septum that is responsible for transiently slowing electrical conduction.
atrioventricular valves  The two valves through which blood flows from the atria to the ventricles.
atrium  Upper chamber of the heart.
auditory ossicles  The bones that function in hearing and are located deep within cavities of the temporal bone.
automacity  The ability of cardiac cells to generate an impulse to contract even when there is no external nervous stimulus.
autonomic nervous system (ANS)  The part of the nervous system that regulates functions, such as digestion and sweating, that are not controlled voluntarily.
axial skeleton  The portion of the skeleton that includes the torso.
axillary nerve  One of the major nerves emanating from the brachial plexus; it supplies the deltoid and teres minor muscles, enabling arm abduction and lateral rotation.
axillary nodes  A large collection of lymph nodes located in the axilla (armpit).
axillary vein  The vein that is formed from the combination of the basilic and cephalic veins; it drains into the subclavian vein.
axis  The second cervical vertebra; the point that allows the head to turn.
axon  A projection from a neuron that makes connections with adjacent cells.
ball-and-socket joint  A joint that allows internal and external rotation as well as bending.
baroreceptors  Receptors in the blood vessels, kidneys, brain, and heart that respond to changes in pressure in the heart or main arteries to help maintain homeostasis.
basal ganglia  Structures located deep within the cerebrum, diencephalon, and midbrain that play an important role in coordination of motor movements and posture.
base  A substance that decreases the concentration of hydrogen ions.
basilar artery  The artery that is formed when the left and right vertebral arteries unite after entering the brain through the foramen magnum.
basilic vein  One of the two major veins of the arm; it combines with the cephalic vein to form the axillary vein.
basophil  A white blood cell that may play a role following infection of various areas in the body.
beta cells  Cells located in the islets of Langerhans that secrete insulin.
beta effects  Stimulation of beta receptors that results in inotropic, dromotropic, and chronotropic states.
beta-endorphins  Proteins that have the same effects as opiate drugs such as morphine.
beta receptors  One of two adrenergic receptors classified into two structural and functional categories; further subdivided into beta1 and beta2 receptors.
bilateral  A body part that appears on both sides of the midline.
bile ducts  Ducts that convey bile between the liver and the intestine.
bilirubin  A waste product of red blood cell destruction that undergoes further metabolism in the liver.

black lung disease  A disease of the lung caused by consistent inhalation of coal dust.

blood  The fluid tissue that is pumped by the heart through the arteries, veins, and capillaries and consists of plasma and formed elements or cells, such as red blood cells, white blood cells, and platelets.

blood pressure (BP)  The pressure that the blood exerts against the walls of the arteries as it passes through them.

blowout fracture  A fracture of the floor of the orbit usually caused by a blow to the eye.

bone marrow  The substance located within the medullary cavity of a bone that consists of adipose tissue (yellow marrow) or red-blood-producing cells in bones in the axial skeleton and girdles (red marrow).

brachial artery  The major vessel in the upper extremity that supplies blood to the arm.

brachial plexus  The plexus of spinal nerves that consists of nerves C5 to T1 and innervates the shoulder and upper extremity.

brain  The controlling organ of the body and center of consciousness; functions include perception, control of reactions to the environment, emotional responses, and judgment.

brainstem  The area of the brain between the spinal cord and cerebrum, surrounded by the cerebellum; controls functions that are necessary for life, such as respirations.

bronchial arteries  Arteries that branch off of the thoracic aorta and supply the lung tissues with blood.

bronchial veins  Veins that return deoxygenated blood to the heart from the lungs.

bronchioles  Fine subdivisions of the bronchi that give rise to the alveolar ducts.

bronchodilator  Medication that is designed to improve lung function.

bronchospasm  Constriction of the airway passages of the lungs that accompanies muscle spasms.

bruit  An abnormal “whooshing-like” sound indicating turbulent blood flow within a blood vessel.

bruxism  Grinding together of the upper and lower teeth.

buffer  Any substance that can reversibly bind H⁺.

buffer systems  Fast-acting defenses for acid-base changes, providing almost immediate protection against changes in the hydrogen ion concentration of extracellular fluid.

bundle of His  Part of the conduction system of the heart; a continuation of the atroventricular node.

bursa  A small fluid-filled sac located between a tendon and a bone that cushions and protects the joint.

calcitonin  A hormone produced by the parafollicular cells of the thyroid gland that is important in the regulation of calcium levels in the body.

canaliculi  A minute canal in a compact bone.

cancellous bone  A lacy network of bony rods called trabeculae.

capillary  The fine end-divisions of the arterial system that allow contact between cells of the body tissues and the plasma and red blood cells.

cardiac cycle  The repetitive pumping process that begins with the onset of cardiac muscle contraction and ends just prior to the beginning of the next contraction.

cardiac muscle  Muscle that is found only in the heart, providing the contractions needed to propel the blood through the circulatory system.

cardiac output  The amount of blood pumped through the circulatory system in 1 minute.

carotid artery  The major artery that supplies blood to the head and brain.

carotid bifurcation  The point of division at which the common carotid artery branches at the angle of the mandible into the internal and external carotid arteries.

carotid canals  An opening in the cranial vault through which the carotid arteries enter.

carpometacarpal joint  The joint between the wrist and the metacarpal bones; the thumb joint.

cartilage  Plates of shiny connective tissue that are lubricated by synovial fluid to provide a slippery surface over which bones may move freely.

catabolism  The destructive component of metabolism associated with the breakdown of larger molecules into smaller molecules.
cauda equina  Numerous individual nerve roots that extend from the spinal cord at the level of the second lumbar vertebra.

caudal  Toward the feet.

cecum  The first part of the large intestine, into which the ileum opens.

cell membrane  The cell wall; the cell membrane is selectively permeable.

cells  The basic building blocks of life; made up of protoplasm or cytoplasm, specialized for particular functions.

cellular respiration  A biochemical process resulting in the production of energy in the form of ATP.

central nervous system (CNS)  The brain and spinal cord.

deadhead  Situated toward the head.

cephalic vein  One of the two major veins of the arm that combine to form the axillary vein.

cerebellar peduncles  One of three bands of nerve fibers through which the cerebellum communicates with other regions of the CNS.

cerebellum  One of the three major subdivisions of the brain, sometimes called the “little brain”; coordinates the various activities of the brain, particularly body movements.

cerebral arteries  The arteries that supply blood to large portions of the cerebral cortex of the brain.

cerebrospinal fluid (CSF)  Fluid produced in the ventricles of the brain that flows in the subarachnoid space and bathes the meninges.

cerebrum  The largest part of the three subdivisions of the brain, sometimes called the “gray matter”; made up of several lobes that control movement, hearing, balance, speech, visual perception, emotions, and personality.

cervical nodes  A large collection of lymph nodes located in the neck.

cervical spine  The portion of the spinal column consisting of the first seven vertebrae that lie in the neck.

chemoreceptors  Receptors in the blood vessels, kidneys, brain, and heart that respond to changes in chemical composition of the blood to help maintain homeostasis.

cholinergic  Description of a neuron that secretes the neurotransmitter acetylcholine.
**conductivity** The ability of cardiac cells to conduct electrical impulses.

**contractility** The strength of heart muscle contraction.

**contralateral** On the opposite side.

**coronal suture** The point where the parietal bones join together with the frontal bone.

**coronary arteries** Arteries that arise from the aorta shortly after it leaves the left ventricle and supply the heart with oxygen and nutrients.

**coronary sinus** Veins that collect blood that is returning from the walls of the heart.

**corticosteroids** Any of several steroids secreted by the adrenal gland.

**cortisol** The most important corticosteroid secreted by the zona fasciculata.

**costal arch** A bridge of cartilage that connects the ends of the sixth through tenth ribs with the lower portion of the sternum.

**costochondritis** Inflammation of the costocartilages, which attach the ribs to the sternum.

**costovertebral angle** An angle that is formed by the junction of the spine and the tenth rib.

**cranial** Related to or toward the skull.

**cranial nerves** The 12 pairs of nerves that arise from the base of the brain.

**cranial vault** The bones that encase and protect the brain, including the parietal, temporal, frontal, occipital, sphenoid, and ethmoid bones.

**cranium** The area of the head above the ears and eyes; the skull. The cranium contains the brain.

**crenation** Shrinkage of a cell that results when too much water leaves the cell through osmosis.

**crepitus** A grinding sound or sensation.

**cribriform plate** A horizontal bone perforated with numerous foramina for the passage of the olfactory nerve filaments from the nasal cavity.

**cricoid cartilage** A firm ridge of cartilage that forms the lower part of the larynx.

**cricothyroid membrane** A thin sheet of fascia that connects the thyroid and cricoid cartilages that make up the larynx.

**crista galli** A prominent bony ridge in the center of the anterior fossa to which the meninges are attached.

**cusps** The flaps that comprise the heart valves.

**deep** Further inside the body and away from the skin.

**deep peroneal nerve** A component and branch of the common peroneal nerve that innervates the muscles that dorsiflex the foot and extend the toes.

**dendrite** A projection from a neuron that makes connections with an adjacent cell.

**dermatome** An area of skin supplied by a given spinal nerve.

**dermis** The inner layer of the skin, containing hair follicles, sweat glands, nerve endings, and blood vessels.

**descending aorta** One of the three portions of the aorta, it is the longest portion and extends through the thorax and abdomen into the pelvis.

**descending fibers (efferent tracts)** Fibers that carry motor impulses from the brain to the fibers of the peripheral nervous system; also called efferent tracts.

**diapedesis** A process whereby leukocytes leave blood vessels to move toward tissue where they are needed most.

**diaphragm** A muscular dome that forms the undersurface of the thorax, separating the chest from the abdominal cavity. Contraction of the diaphragm (and the chest wall muscles) brings air into the lungs. Relaxation allows air to be expelled from the lungs.

**diaphysis** The shaft of a long bone.

**diastole** The relaxation, or period of relaxation, of the heart, especially of the ventricles.

**diencephalon** The part of the brain between the brainstem and the cerebrum that includes the thalamus, the subthalamus, hypothalamus, and epithalamus.

**diffuse lymphatic tissue** Tissue with no clear boundary that blends with surrounding tissues and contains lymphocytes and other cells.

**diffusion** Movement of particles or solutes.

**digestion** The processing of food that nourishes the individual cells of the body.

**distal** Structures that are farther from the trunk or nearer to the free end of the extremity.

**dorsal** The posterior surface of the body, including the back of the hand.

**dorsal root** One of two roots of a spinal nerve that passes posteriorly into the spinal cord and contains the dorsal root ganglion.
dorsal root ganglion  A ganglion on the dorsal root of each spinal nerve.
dorsalis pedis artery  The artery on the anterior surface of the foot between the first and second metatarsals.
dromotropic state  Related to the control of the heart’s conduction rate.
dura mater  The outermost of the three meninges that enclose the brain and spinal cord; it is the toughest membrane.
efferent nerves  Nerves that carry commands from the brain to peripheral muscles also called motor nerves.
ejection fraction  The portion of the blood ejected from the ventricle during systole.
electrolytes  Salt or acid substances that become ionic conductors when dissolved in a solvent (ie, water); chemicals dissolved in the blood.
emphysema  Destruction of the walls of the alveoli, which creates resistance to expiratory airflow.
endochondral growth  The growth of cartilage in the epiphyseal plate and its eventual replacement by bone; one of the ways a bone grows.
endocrine glands  Glands that empty secretions (hormones) directly into the blood.
endocrine system  The complex message and control system that integrates many body functions, including the release of hormones.
endocytosis  The uptake of material through the cell membrane by a membrane-bound droplet or vesicle formed within the cell’s protoplasm.
endosteum  The lining of the inner surfaces of a long bone.
eosinophils  A leukocyte that may play a role following infection in various areas in the body.
epicardium  The layer of the serous pericardium that lies closely against the heart. Also called the visceral pericardium.
epidermis  The outer layer of skin, which is made up of cells that are sealed together to form a watertight protective covering for the body.
epiglottis  A thin, leaf-shaped valve that allows air to pass into the trachea but prevents food or liquid from entering.
epinephrine  A naturally occurring hormone with a greater stimulatory effect on beta receptors that also may be given as a cardiac drug.
epiphyses  The ends of a long bone.
epithalamus  Part of the diencephalon with uncertain functions.
erthrocytes  Disk-shaped cells that carry oxygen to the tissues; also known as red blood cells.
erthropoiesis  The process by which red blood cells are made.
esophagus  A collapsible tube that extends from the pharynx to the stomach; contractions of the muscle in the wall of the esophagus propel food and liquids through it to the stomach.
estrogen  Produced by the ovaries, it is one of three major female hormones.
excitability  A property of cardiac cells that provides the cells with the ability to respond to electrical impulses.
exocrine glands  Glands that empty their products through ducts, usually onto epithelial surfaces.
exocytosis  The release of secretions from cells that have been accumulated in vesicles.
extend  To straighten.
extension  Return of a joint from a flexed position to an anatomic position.
external auditory meatus  An opening in the temporal bone that contains the ear canal.
external nares  The external openings to the nasal cavity; also called the nostrils.
external rotation  Rotating an extremity at its joint away from the midline.
extracellular fluid (ECF)  Fluid outside of the cell, in which most of the body’s supply of sodium is contained.
facial nerve  The cranial nerve (VII) that supplies motor activity to all muscles of facial expression, the sense of taste to the anterior two thirds of the tongue, and cutaneous sensation to the external ear, tongue, and palate.
facilitated diffusion  Process whereby a carrier molecule moves substances in or out of cells from areas of higher to lower concentration.
fallopian tube  Long, slender tube that extends from the uterus to the region of the ovary on the same side, and through which the ovum passes from ovary to uterus.
fascia  A sheet or band of tough fibrous connective tissue that covers, supports, and separates muscles.

feedback inhibition  The concept that once the desired effect of a hormone has been achieved, further production of the hormone is inhibited until it is needed again; also referred to as negative feedback.

femoral artery  The principal artery of the thigh, a continuation of the external iliac artery. It supplies blood to the lower abdominal wall, external genitalia, and legs. It can be palpated in the groin area.

femoral head  The proximal end of the femur, articulating with the acetabulum to form the hip joint.

femoral nerve  The branch of the lumbosacral plexus that innervates the muscles that flex the hip and extend the knee.

femoral vein  A continuation of the saphenous vein that drains into the external iliac vein.

femur  The thighbone; the longest and one of the strongest bones in the body.

fibrin  A white insoluble protein formed in the clotting process.

fibula  The long bone on the posterior surface of the lower leg.

flat bones  Type of bone that is relatively thin and flattened.

flex  To bend.

flexion  In the anatomic position, moving a distal point of an extremity closer to the trunk.

flexor reflex  A withdrawal reflex in the flexor muscles of the limbs that contract in response to an unpleasant stimulus.

floating ribs  The eleventh and twelfth ribs, which do not attach to the sternum through the costal arch.

fluid balance  The process of maintaining homeostasis through equal intake and output of fluids.

follicles  Small cavity glands within the thyroid gland that contain thyroglobulin.

follicle-stimulating hormone (FSH)  Hormone that regulates the production of both eggs and sperm, as well as production of reproductive hormones.

fontanelles  The soft spots in the skull of a newborn and infant where the sutures of the skull have not yet grown together.

foramen magnum  A large opening at the base of the skull through which the brain connects to the spinal cord.

foramen ovale  An opening between the two atria that is present in the fetus but closes shortly after birth.

foramina  Small openings, perforations, or orifices in the bones of the cranial vault.

forced expiratory vital capacity (FEV1)  The volume of air exhaled from the lung following a forceful exhalation.

fossa ovalis  A depression between the right and left atria that indicates where the foramen ovale had been located in the fetus.

Fowler's position  The position in which the patient is sitting up with the knees bent.

frontal lobe  The portion of the brain that is important in voluntary motor actions and personality traits.

frontal plane  The plane parallel to the anterior surface of the body.

gallbladder  A sac on the undersurface of the liver that collects bile from the liver and discharges it into the duodenum through the common bile duct.

ganglia  Collections of nerve cell bodies located outside the CNS.

ganglionic synapse  A separation between two nerves (preganglionic and postganglionic neurons), in a series between the CNS and the organs innervated.

genital system  The male and female reproductive systems.

glottis  The opening into the lower airway between the true vocal cords.

glucagon  Hormone produced by the pancreas that is vital to the control of the body’s metabolism and blood glucose level.
**glucocorticoids**  Hormones secreted by the zona fasciculata that play an important role in metabolism and inhibit inflammation.

**gluconeogenesis**  A process that stimulates both the liver and the kidneys to produce glucose from non-carbohydrate molecules.

**glycogen**  A long polymer from which glucose is converted in the liver (animal starch).

**glycogenolysis**  The breakdown of glycogen to glucose.

**gonadotropin-releasing hormone**  A hormone released by the hypothalamus that influences the release of LH and FSH.

**gonads**  The reproductive glands.

**granulocytes**  A type of leukocyte that has large cytoplasmic granules that are easily seen with a simple light microscope.

**greater trochanter**  A bony prominence on the proximal lateral side of the thigh, just below the hip joint.

**growth hormone (GH)**  Hormone that stimulates growth in most tissues, especially of long bones in the extremities; also called somatotropin.

**growth hormone release-inhibiting hormone**  Hormone released by the hypothalamus that inhibits the secretion of growth hormone; also called somatostatin.

**growth hormone-releasing hormone**  A hormone released by the hypothalamus that stimulates the secretion of growth hormone.

**gyri**  The numerous folds in the cerebrum, which greatly increase the surface area of the cortex.

**hair follicles**  The small organs in the skin that produce hair.

**hard palate**  The bony anterior part of the palate, which forms the roof of the mouth.

**haversian systems**  A unit of compact bone consisting of a tube (haversian canal) with the laminae of bone that surrounds it.

**heart**  A hollow muscular organ that receives blood from the veins and propels it into the arteries.

**hemoglobin**  An iron-containing pigment found in red blood cells, carries 97% of oxygen.

**hemostasis**  Control of bleeding by formation of a blood clot.

**heparin**  A substance found in large amounts in basophils that inhibits blood clotting.

**hepatic portal system**  A specialized part of the venous system that drains blood from the stomach, intestines, and spleen.

**hepatic veins**  The veins to which blood empties after liver cells in the sinusoids of the liver extract nutrients, filter the blood, and metabolize various drugs.

**hilium**  The point of entry for the bronchi, vessels, and nerves into each lung.

**hinge joints**  Joints that can bend and straighten but cannot rotate; they restrict motion to one plane.

**histamine**  A substance found in large amounts in basophils that increases tissue inflammation.

**homeostasis**  The maintenance of a relatively stable internal physiologic environment.

**hormone sensitive lipase**  An enzyme that is activated by glucagons; it breaks triglycerides down into free fatty acids and glycerol.

**hormones**  Proteins secreted by glands to regulate body functions.

**human chorionic gonadotropin (hCG)**  One of three major female hormones; it is produced by a developing embryo after conception.

**humerus**  The supporting bone of the arm.

**hydroxyapatite**  A mineral compound containing calcium and phosphate that, along with collagen, comprises the structural element of bone.

**hyoid bone**  A bone at the base of the tongue that supports the tongue and its muscles.

**hyperextension**  Extension of a body part to a maximum level or past the position of normal extension.

**hyperflexion**  Flexion of a body part to a maximum level or past the position of normal flexion.

**hyperosmolar hyperglycemic nonketotic coma (HHNC)**  A diabetic emergency that occurs from a relative insulin deficiency, resulting in marked hyperglycemia but the absence of ketones and acidosis.

**hypoglossal nerve**  The cranial nerve (XII) that provides motor function to the muscles of the tongue and throat.

**hypophysis**  The gland that secretes hormones that regulate the function of many other glands in the body; also called the pituitary gland.
hypothalamic-pituitary-adrenal axis  A complex set of interactions that regulates the secretion of corticosteroids.

hypothalamic-pituitary axis  The interactions of the hypothalamus and the pituitary gland.

hypothalamohypophyseal portal system  A specialized set of blood vessels that carry releasing factors from the hypothalamus to the anterior pituitary lobe.

hypothalamus  The basal part of the diencephalons; it regulates the function of the pituitary gland.

hypoxic drive  A “backup system” to control respiration; senses drops in the oxygen level in the blood.

iliac crest  The rim, or wing, of the pelvic bone.

illium  One of three bones that fuse to form the pelvic ring.

inferior  The part of the body, or any body part, nearer to the feet.

inferior vena cava  One of the two largest veins in the body; carries blood from the lower extremities and the pelvic and the abdominal organs into the heart.

inguinal ligament  The tough, fibrous ligament that stretches between the lateral edge of the pubic symphysis and the anterosuperior iliac spine.

inguinal nodes  A large collection of lymph nodes located in the groin.

inhibiting factors  Compounds that travel from the hypothalamus to the pituitary gland in a specialized set of blood vessels; also called releasing factors.

inotropic state  Related to the strength of the heart’s contraction.

insulin  Hormone produced by the pancreas that is vital in the control of the body’s metabolism and blood glucose level.

integumentary system  The body’s external surface, including the skin, nails, hair, and sweat and oil glands.

interatrial septum  A membrane that separates the right and left atria.

interior nares  The posterior opening from the nasopharynx into the pharynx.

internal auditory meatus  A short canal through which auditory and facial nerves pass.

internal rotation  Rotating an extremity medially toward the midline.

interstitial fluid  The fluid located outside of the blood vessels in the spaces between the body’s cells.

interventricular septum  A thick wall that separates the right and left ventricles.

intervertebral foramen  The opening between each vertebra through which the spinal (peripheral) nerves pass from the spinal cord.

intracellular fluid (ICF)  Fluid within cells in which most of the body’s supply of potassium is contained.

intravascular fluid (plasma)  The noncellular portion of blood found within the blood vessels; also called plasma.

involuntary  Not normally under conscious control.

involuntary muscle  Muscle that continues to contract, rhythmically, regardless of the conscious will of the individual.

ipsilateral  On the same side.

islets of Langerhans  A specialized group of cells in the pancreas where insulin and glucagon are produced.

isthmus  A narrow bank of tissue that connects the two lobes of the thyroid gland.

joint (articulation)  The place where two bones come into contact.

joint capsule  The fibrous sac with synovial lining that encloses a joint.

jugular veins  The two main veins that drain the head and neck.

kidneys  Two retroperitoneal organs that excrete the end products of metabolism as urine and regulate the body’s salt and water content.

Krebs cycle  A sequence of reactions in an organism in which oxidation of acids provides energy for storage in phosphate bonds (as in ATP); also called the tricarboxylic acid cycle.

lacuna  One of the minute cavities in bone or cartilage occupied by osteocytes.

lambdoid suture  The point where the occipital bones attach to the parietal bones.

lamellae  Thin sheets or layers into which bone tissue is organized.

large intestine  The portion of the digestive tube that encircles the abdomen around the small bowel, consisting of the cecum, the colon, and the rectum.
larynx  The opening of the lower airway, which consists of several cartilaginous structures held together by ligaments.
lateral  Parts of the body that lie farther from the mid-line; also called outer structures.
lateral malleolus  An enlargement of the distal end of the fibula, which forms the lateral wall of the ankle joint.
lateral recumbent position  Lying on the side.
left anterior descending  One of the two branches of the left main coronary artery that is the largest and shortest of the myocardial blood vessels. The LAD and the circumflex coronary arteries supply blood to the left ventricle and other areas.
leukocytes  White blood cells that are responsible for fighting infection.
ligament  A band of the fibrous tissue that connects bones to bones; it supports and strengthens a joint.
limbic system  Structures within the cerebrum and diencephalon that influence emotions, motivation, mood, and sensations of pain and pleasure.
lingual tonsils  One of three sets of lymphatic organs that comprise the tonsils; they are located on the posterior margin of the tongue and help protect the body from bacteria introduced into the mouth and nose.
lingula  A small portion of the left lung that is the equivalent of the middle lobe in the right lung.
liver  A large solid organ that lies in the right upper quadrant immediately below the diaphragm; it produces bile, stores sugar for immediate use by the body, and produces many substances that help regulate immune responses.
lobes  Subdivisions within each hemisphere of the cerebrum; each lobe is named for the bone of the skull that overlies it.
long bones  Type of bone that is longer than it is wide.
longitudinal fissure  The crevasse that separates the right and left hemispheres of the cerebrum.
lumbar spine  The lower part of the back, formed by the lowest five nonfused vertebrae; also called the dorsal spine.
lumbar vertebrae  Vertebrae of the lumbar spine.
lumbosacral plexus  A combination of the lumbar plexus and the sacral plexus and the coccygeal root.
lungs  The two primary organs of breathing.
luteinizing hormone (LH)  A hormone released from the pituitary gland at roughly monthly intervals that helps to stimulate one oocyte to undergo meiosis.
lymph  A thin, plasma-like liquid formed from interstitial or extracellular fluid that bathes the tissues of the body.
lymph nodes  Round or bean-shaped structures interspersed along the course of the lymph vessels, which filter the lymph and serve as a source of lymphocytes.
lymph nodules  Tissue that is denser than diffuse lymphatic tissue, found in the loose connective tissue of the digestive, respiratory, and urinary systems.
lymph vessels  Thin-walled vessels through which lymph circulates through the body; they travel close to the major veins.
lymphatic capillaries  Vessels of the lymphatic system that carry fluid away from the tissues.
lymphatic duct  One of two great lymph vessels; it empties into the subclavian vein.
lymphatic system  A passive circulatory system that transports a plasma-like liquid called lymph, a thin fluid that bathes the tissues of the body.
lymphocytes  The smallest of the agranulocytes, they originate in the bone marrow but migrate through the blood to the lymphatic tissues.
lysis  The process of disintegration or breakdown of cells that occurs when excess water enters the cell through osmosis.
macrophages  Cells that are responsible for protecting the body against infection.
mainstem bronchi  The part of the lower airway below the larynx through which air enters the lungs.
mandible  The bone of the lower jaw.
manubrium  The upper quarter of the sternum.
mastoid process  A prominent bony mass at the base of the skull behind the ear.
maxillae  The upper jawbones that assist in the formation of the orbit, the nasal cavity, and the palate, and lodge the upper teeth.
meatus  A passage located below each turbinate.
medial  Parts of the body that lie closer to the mid-line; also called inner structures.
medial malleolus  The distal end of the tibia, which forms the medial side of the ankle joint.
The nerve in the brachial plexus that innervates the pronator muscles of the forearm, as well as those that flex the wrist, fingers, and thumb.

An imaginary longitudinal line that divides the human body into left and right parts; also called the midsagittal plane or the midline.

The space between the lungs, in the center of the chest, that contains the heart, trachea, mainstem bronchi, part of the esophagus, and large blood vessels.

The inner portion of the adrenal glands, which produce epinephrine and norepinephrine.

The inferior portion of the midbrain, which serves as a conduction pathway for both ascending and descending nerve tracts.

The internal cavity of the diaphysis of a long bone that contains bone marrow.

A set of three tough membranes, the dura mater, arachnoid, and pia mater, that enclose the entire brain and spinal cord.

The sum of all the physical and chemical processes of living organisms; the process by which energy is made available for the uses of the organism.

The bones that form the hand.

The area of a long bone where the diaphysis and epiphysis converge; the epiphyseal plate is located here.

An imaginary vertical line drawn through the middle of the axilla (armpit), parallel to the midline.

An imaginary vertical line drawn through the middle portion of the clavicle and parallel to the midline.

An imaginary vertical line drawn from the middle of the forehead through the nose and the umbilicus (navel) to the floor.

Hormones produced in the zona glomerulosa that are important in the regulation of water and salt balance in the body.

Small rod-like organelle that functions as the metabolic center of the cell and produce ATP.

The valve in the heart that separates the left atrium from the left ventricle.

Migrate out of the blood and into the tissues in response to an infection.

Nerves that carry information from the central nervous system to the muscles of the body.

The lining of body cavities and passages that communicate directly or indirectly with the environment outside the body.

The opaque, sticky secretion of the mucous membranes that lubricates the body openings.

An abnormal heart sound, heard as a “whooshing-like” sound indicating turbulent blood flow within the heart.

Receptors at the target tissue that are stimulated by acetylcholine and can also be stimulated in the laboratory by the compound extracted from muscarine mushrooms.

A nerve in the upper extremity that innervates muscles that flex the arm and forearm.

The bones and voluntary muscles of the body.

Blockage of the arteries that supply oxygen to the heart, resulting in death to a portion of the myocardium.

The heart muscle.

The chamber inside the nose that lies between the floor of the cranium and the roof of the mouth.

The separation between the right and left nostrils.

The ducts that drain tears from the lacrimal sac to the meatus.

The part of the pharynx that lies above the level of the roof of the mouth, or soft palate.

The concept that once the desired effect of a hormone has been achieved, further production of the hormone is inhibited until it is needed again; also called feedback inhibition.

Nervous tissue that connects the nervous system with body parts or organs.

Groups of nerves cells bundled together.

The system that controls virtually all activities of the body, both voluntary and involuntary.
neuroeffector cells  The target tissues of the autonomic nervous system.

neuroglia  Collectively, the name for the connective and supporting tissues of the nervous tissue.

neurohormones  Hormones secreted by the posterior pituitary lobe.

neuromuscular junction  The junction between a motor neuron and a muscle fiber; one type of a synapse.

neurons  The main functional units of the nervous system.

neurotransmitters  Chemical substances that transmit nerve impulses across a synapse.

neutrophils  One of the three types of granulocytes; they have multi-lobed nuclei that resemble a string of baseballs held together by a thin strand of thread; they destroy bacteria, antigen-antibody complexes, and foreign matter.

nicotinic receptors  Receptors in the postganglionic neuron that can be stimulated in the laboratory by the alkaloid nicotine.

nonstriated  Smooth muscle tissue.

norepinephrine  A naturally occurring hormone with a greater stimulatory effect on alpha receptors that also may be given as a cardiac drug.

obturatory nerve  A nerve emanating from the lumbarosacral plexus that innervates muscles that adduct the thigh and rotate it medially.

ocular condyles  Articular surface on the occipital bone where the skull articulates with the atlas on the vertebral column.

occipital lobe  The portion of the brain that is responsible for the processing of visual information.

oculomotor nerve  The cranial nerve (III) that innervates the muscles that cause motion of the eyeballs and upper lid.

olfactory bulb  The cranial nerve for smell.

olfactory nerve  The cranial nerve (I) that transmits information about the sense of smell.

olfactory tract  The part of the olfactory nerve that arises at the base of the brain.

optic chiasma  A continuation of the optic nerve, which forms an “X” under the hypothalamus.

optic foramina  The openings through which the optic nerves pass to reach each eyeball.

optic nerve  The cranial nerve (II) that transmits visual information to the brain.

optic tracts  The parts of the optic nerve that arise at the base of the brain, forming the optic chiasma.

orbit  The eye socket, made up of the maxilla and zygoma.

organ  Different types of tissues working together to perform a particular function.

organism  Any living thing considered as a whole, made up of various organ systems.

organ system  A group of organs that have a common purpose, such as the skeleton, muscles, and the circulatory and respiratory systems, among others.

oropharynx  A tubular structure that extends vertically from the back of the mouth to the esophagus and trachea.

osmoreceptors  Specialized neurons in the brain that regulate the secretion of ADH.

osmosis  The movement of a solvent, such as water, from an area of low solute concentration to one of high concentration through a selectively permeable membrane to equalize concentrations of a solute on both sides of the membrane.

osmotic pressure  The tendency of water to move by osmosis across a membrane.

ossicles  The three small bones in the middle ear: the malleus, incus, and stapes.

osteoblasts  Bone-forming cells.

osteoclasts  Large, multinucleated cells that dissolve bone tissue and play a major role in bone remodeling.

osteocyte  An osteoblast that becomes surrounded by bony matrix.

osteons  Unit within a compact bone in which blood vessels are located; also called the haversian system.

ovary  A female gland that produces sex hormones and ova (eggs).

oxytocin  A hormone that causes the smooth muscles of the pregnant uterus to contract and milk to be released from the breasts of lactating women.

palatine bone  An irregularly shaped bone found in the posterior part of the nasal cavity.
**palatine tonsils**  One of three sets of lymphatic organs that comprise the tonsils; they are located in the back of the throat, on each side of the posterior opening of the oral cavity, and help protect the body from bacteria introduced into the mouth and nose.

**palmar**  The front region of the hand.

**palmar arches**  The two arches formed from the radial and ulnar vessels within the hand, creating the superficial and deep palmar arches.

**pancreas**  A flat, solid organ that lies below the liver and the stomach; it is a major source of digestive enzymes and produces the hormone insulin.

**papillary muscles**  Specialized muscles that attach the ventricles to the cusps of the valves by muscular strands called chordae tendineae cordis.

**parafollicular cells**  Cells located between the follicles in the thyroid gland that produce the hormone calcitonin.

**paranasal sinuses**  The sinuses, or hollowed sections of bone in the front of the head, which are lined with mucous membrane and drain into the nasal cavity.

**parasympathetic nervous system**  The part of the autonomic nervous system that relaxes the body.

**parathyroid glands**  Four glands that are embedded in the posterior portion of each lobe of the thyroid; they produce and secrete parathyroid hormone.

**parathyroid hormone**  Hormone produced and secreted by the parathyroid glands; it maintains normal levels of calcium in the blood and normal neuromuscular function.

**parietal layer**  One of two layers of the serous pericardium; it is separated from the visceral pericardium by a small amount of pericardial fluid.

**parietal lobe**  The portion of the brain that is the site for reception and evaluation of most sensory information, except smell, hearing, and vision.

**parietal pleura**  The pleural membrane that lines the pleural cavity.

**partial pressure of carbon dioxide (Paco₂)**  A measurement of the amount of carbon dioxide in the blood.

**partial pressure of oxygen (Pao₂)**  A measurement of the amount of oxygen in the blood.

**patella**  The kneecap; a specialized bone that lies within the tendon of the quadriceps muscle.

**pathophysiology**  The study of body functions of a living organism in an abnormal state.

**pelvis**  The attachment of the lower extremities to the body, consisting of the sacrum and two pelvic bones.

**perfusion**  The circulation of blood within an organ or tissue in adequate amounts to meet the cells’ current needs.

**pericardial fluid**  A serous fluid that fills the space between the visceral pericardium and the parietal pericardium and helps to reduce friction.

**pericardial sac**  The potential space between the layers of the pericardium.

**pericardium**  The serous membranes that surround the heart.

**periosteum**  The membrane, made up of a double layer of connective tissue, that covers all bones, except the articular surfaces.

**peripheral nerves**  The nerves that extend from the brain and spinal cord to various parts of the body by exiting between the vertebrae of the spine.

**peripheral nervous system**  The part of the nervous system that consists of 31 pairs of spinal nerves and 12 pairs of cranial nerves; these peripheral nerves may be sensory nerves, motor nerves, or connecting nerves.

**peristalsis**  The wave-like contraction of smooth muscle by which the ureters or other tubular organs propel their contents.

**pH**  The measure of acidity or alkalinity of a solution.

**phagocytosis**  Endocytosis involving solid particles.

**phalanges**  The small bones of the digits of the fingers and toes.

**pharyngeal tonsils**  One of three sets of lymphatic organs that comprise the tonsils; they are located near the internal opening of the nasal cavity and help protect the body from bacteria introduced into the mouth and nose. Also called adenoids.

**pharynx**  The cavity formed by the posterior connection of the oropharynx and nasopharynx.

**physiology**  The study of the body functions of the living organism.
 Prep Kit continued...

**Physis**  The major site of bone elongation, located just proximal to the bone ends; also called the growth plate.

**Pia mater**  The innermost of the three meninges that enclose the brain and spinal cord; it rests directly on the brain and spinal cord.

**Pineal body**  Part of the epithalamus in the diencephalon.

**Pinocytosis**  Endocytosis involving liquid.

**Pituitary gland**  An endocrine gland, located in the sella turcica of the brain, responsible for directly or indirectly affecting all body functions.

**Planes**  Imaginary surfaces used as references to identify parts of the body.

**Planter**  The bottom of the foot.

**Plasma**  A sticky, yellow fluid that carries the blood cells and nutrients and transports cellular waste material to the organs of excretion.

**Plasmin**  An enzyme that dissolves the fibrin in blood clots.

**Platelets**  Tiny, disk-shaped elements that are much smaller than the cells; they are essential in the initial formation of a blood clot, the mechanism that stops bleeding.

**Pleura**  The serous membrane covering the lungs and lining the thoracic cavity, completely enclosing a potential space known as the pleural space.

**Pleural cavity**  The potential space between the visceral and parietal pleura.

**Pleural space**  The potential space between the parietal pleura and the visceral pleura. It is described as “potential” because under normal conditions, the lungs fill this space.

**Plexus**  An organized intermingling formed by several nerves.

**Pons**  The mass of nerve fibers at the end of the medulla oblongata.

**Popliteal artery**  A continuation of the femoral artery at the knee.

**Popliteal vein**  The vein that forms when the anterior and posterior tibial veins unite at the knee.

**Positive feedback**  The concept that once the desired effect of a hormone has been achieved, production of the hormone is continued.

**Posterior**  The back surface of the body; the side away from you in the standard anatomic position.

**Posterior pituitary lobe (neurohypophysis)**  One of the two portions of the pituitary gland; it is an extension of the central nervous system and produces hormones called neurohormones; also called the neurohypophysis.

**Posterior tibial artery**  The artery just posterior to the medial malleolus; supplies blood to the foot.

**Postganglionic neuron**  The second of two nerves, separated by a ganglionic synapse, in a series between the CNS and the organs that are innervated.

**Postsynaptic terminal**  The proximal portion of the muscle fiber in the neuromuscular junction.

**Preganglionic neuron**  The first of two nerves, separated by a ganglionic synapse, in a series between the CNS and the organs that are innervated.

**Preload**  The volume of blood returned to the heart.

**Presynaptic terminal**  The distal end of the nerve fiber in the neuromuscular junction.

**Priapism**  A continuous and painful erection of the penis caused by certain spinal injuries and some diseases.

**Progesterone**  A hormone released from the ovaries that stimulates the uterine lining during the menstrual cycle.

**Prolactin**  Hormone that plays an important role in milk production in women.

**Prolactin-inhibiting hormones**  Hormones released by the hypothalamus that influence inhibition of prolactin.

**Prolactin-releasing hormones**  Hormones released by the hypothalamus that influence the release of prolactin.

**Pronation**  When the palm faces downward.

**Prone position**  The position in which the body is lying face down.

**Prostaglandins**  A group of hormone-like fatty acids that are produced in many body tissues, including the uterus, brain, and kidneys.

**Prostate gland**  A small gland that surrounds the male urethra where it emerges from the urinary bladder; it secretes a fluid that is part of the ejaculatory fluid.

**Proximal**  Structures that are closer to the trunk.

**Public symphysis**  A hard bony prominence that is found in the midline in the lowermost portion of the abdomen.
pulmonary artery  The major artery leading from the right ventricle of the heart to the lungs; it carries oxygen-poor blood.
pulmonary circulation  The circulatory system in the body that carries blood from the right side of the heart to the lungs, and back to the left side of the heart.
pulmonary function tests  Tests that assess volumes of air that move into and out of the lungs.
pulmonary veins  The four veins that return oxygenated blood from the lungs to the left atrium of the heart.
pulmonic valve  The semilunar valve that regulates blood flow between the right ventricle and the pulmonary artery.
pulse  The wave of pressure created as the heart contracts and forces blood out the left ventricle and into the major arteries.
radial artery  The major artery in the forearm; it is palpable at the wrist on the thumb side.
radiation  One of the major nerves in the upper extremity; it supplies muscles that extend the elbow, supinate the forearm, and extend the wrist, fingers, and thumb.
radius  The bone on the thumb side of the forearm.
rami  The posterior vertical parts of the lower jaw that join the mandible.
range of motion (ROM)  The arc of movement of an extremity at a joint in a particular direction.
rectum  The lowermost end of the colon.
red blood cells  Cells that carry oxygen to the body’s tissues; also called erythrocytes.
releasing factors  Compounds that travel from the hypothalamus to the pituitary gland in a specialized set of blood vessels; also called inhibiting factors.
renal pelvis  A cone-shaped collecting area that connects the ureter and the kidney.
renin-angiotensin system  System located in the kidney that helps to regulate fluid balance and blood pressure.
residual volume  The volume of air remaining in the respiratory passages and lungs after a forceful expiration.
respiratory bronchioles  Structures formed by the final branching of the bronchioles.
respiratory center  The part of the brain located in the medulla oblongata that controls the respiratory stimulus.
respiratory system  All the structures of the body that contribute to the process of breathing, consisting of the upper and lower airways and their component parts.
restrictive lung disease  Diseases such as black lung disease, asbestosis, that result in stiffening of the lungs and significantly decreased vital capacity.
retroperitoneal  Behind the abdominal cavity.
retroperitoneum  The space behind the peritoneum.
rerootlets  Small nerves.
sacrum  One of three bones (sacrum and two pelvic bones) that make up the pelvic ring; consists of five fused sacral vertebrae.
saddle joint  Two saddle-shaped articulating surfaces oriented at right angles to each other so that complementary surfaces articulate with each other, such as is the case with the thumb.
sagittal plane  A vertical plane that is parallel to the midline and divides the body into unequal left and right parts.
sagittal suture  The point of the skull where the parietal bones join together.
salivary glands  The glands that produce saliva to keep the mouth and pharynx moist.
saphenous vein  The longest vein in the body, it drains the leg, thigh, and dorsum of the foot.
sacrum  The thick skin covering the cranium, which usually bears hair.
scapula  The shoulder blade.
sciatic nerve  The longest peripheral nerve in the body, formed by the combination of the common peroneal nerve and the tibial nerve.
sebaceous glands  Glands that produce an oily substance called sebum, which discharges along the shafts of the hairs.
secondary bronchi  Airway passages in the lungs that are formed from the division of the right and left main-stem bronchi.
selective permeability  Allowing some but not all substances to pass through a membrane to maintain homeostasis.

sella turcica  A depression in the middle of the sphenoid bone where the pituitary gland is located.

semen  Seminal fluid ejaculated from the penis and containing sperm.

semi-Fowler’s position  The position in which the patient is sitting up at a 45° angle with the knees bent.

semilunar valves  The two valves, the aortic and pulmonic valves, that divide the heart from the aorta and pulmonary arteries.

seminal vesicles  Storage sacs for sperm and seminal fluid, which empty into the urethra at the prostate.

sensory nerves  The nerves that carry sensations of touch, taste, heat, cold, pain, or other modalities from the body to the central nervous system.

serous pericardium  The inner membrane of the pericardium, which contains two layers called the visceral pericardium and the parietal pericardium.

serum osmolality  The number of osmotically active particles in serum.

shock position  The position that has the head and torso (trunk) supine and the lower extremities elevated 8" to 12". This helps to increase blood flow to the brain; also referred to as the modified Trendelenburg's position.

short bones  Type of bone that is as broad as it is long.

shoulder girdle  The proximal portion of the upper extremity, made up of the clavicle, the scapula, and the humerus.

shoulder joint  A ball-and-socket joint consisting of the head of the humerus and the glenoid fossa.

sinoatrial (SA) node  The normal site of the origin of electrical impulses; located high in the right atrium, it is the heart's natural pacemaker.

sinusitis  An inflammation of the paranasal sinuses.

sinusoids  The part of the hepatic portal system in which blood collects within the liver and the liver cells extract nutrients from the blood, filter the blood, and metabolize various drugs.

skeletal muscle  Muscle that is attached to bones and usually crosses at least one joint; striated, or voluntary, muscle.

skeleton  The framework that gives us our recognizable form; also designed to allow motion of the body and protection of vital organs.

skull  The structure at the top of the axial skeleton that houses the brain and consists of the 28 bones that comprise the auditory ossicles, the cranium, and the face.

small intestine  The portion of the digestive tube between the stomach and the cecum, consisting of the duodenum, jejunum, and ileum.

smooth muscle  Nonstriated, involuntary muscle; it constitutes the bulk of the gastrointestinal tract and is present in nearly every organ to regulate automatic activity.

solute  Particles, such as salts, that are dissolved in a solvent.

somatomedins  Proteins produced in the liver, skeletal muscle, and other tissues that are stimulated by growth hormone.

somatostatin  A hormone released by the hypothalamus that inhibits the secretion of growth hormone; also called growth hormone release-inhibiting hormone.

somatotropin  Hormone that stimulates growth in many tissues, especially of long bones in the extremities; also called growth hormone (GH).

spinal accessory nerve  The cranial nerve (XI) that provides motor innervation to the muscles of the soft palate and the pharynx and to the sternocleidomastoid and trapezius muscles.

spinal cord  An extension of the brain, composed of virtually all the nerves carrying messages between the brain and the rest of the body; it lies inside of, and is protected by, the spinal canal.

spinal nerves  Nerves in the peripheral nervous system that arise from numerous rootlets along the dorsal and ventral surfaces of the spinal cord.

spinal reflex arcs  Automatic reactions to stimuli that occur without conscious thought.

spirometer  A device used in pulmonary function testing that measures air entering and leaving the lungs over a specific period of time.

spleen  An organ of the lymphatic system that is located in the left upper quadrant of the abdomen and consists of two types of lymph tissue that are associated with drainage of the spleen.

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Starling’s Law of the Heart  The force of the heartbeat is determined primarily by the length of the fibers constituting its muscular wall. An increase in diastolic filling equals an increase in the force of the heartbeat.

sternocleidomastoid muscles  The muscles on either side of the neck that allow movement of the head.

sternum  The breastbone.

striated  Striped.

striated muscle  Muscle that has characteristic stripes, or striations, under the microscope; voluntary, or skeletal, muscle.

stroke volume  The amount of blood that the left ventricle ejects into the aorta per contraction.

styloid process  Several long, slender, and pointed bones that project downward and forward from the temporal bone; also, the small bony protrusion to which the ligaments of the wrist are attached.

subarachnoid hemorrhage  A hemorrhage between the arachnoid membrane and the pia mater.

subarachnoid space  The space located between the pia mater and the arachnoid mater.

subclavian artery  The proximal part of the main artery of the arm, which supplies the brain, neck, anterior chest wall, and shoulder.

subclavian veins  The proximal part of the main vein of the arm, which unites with the internal jugular vein.

subcutaneous tissue  Tissue, largely fat, that lies directly under the dermis and serves as an insulator of the body.

substantia nigra  A layer of gray matter located in the midbrain.

subthalamus  The part of the diencephalon that is involved in controlling motor functions.

sulci  Grooves located between the gyri in the cerebrum.

superficial  Closer to or on the skin.

superficial peroneal nerve  The nerve in the leg that innervates the muscles of foot inversion.

superior  The part of the body, or any body part, nearer to the head.

superior oblique muscle  The muscle that controls the downward gaze of the eyeball.

superior vena cava  One of the two largest veins in the body; carries blood from the upper extremities, head, neck, and chest into the heart.

supination  When the palm faces upward.

supine position  The position in which the body is lying face up.

sutures  Attachment points in the skull where the cranial bones join together.

sweat glands  The glands that secrete sweat.

sympathetic pathway  The part of the autonomic nervous system that is responsible for the body’s response to shock and stress.

synapse  A gap between nerve cells across which nervous stimuli are transmitted.

synaptic cleft  The space between nerves and muscles in the neuromuscular junction across which a nerve impulse is transmitted by a neurotransmitter.

synaptic vesicles  Vesicles that contain neurotransmitters.

synovial fluid  The transparent viscous lubricating fluid secreted by the synovial membrane in an articulation.

systemic circulation  The circulatory system in the body that is responsible for blood flow in all areas of the body, except for areas covered by the pulmonary circulation (blood flow from the right side of the heart to the lungs, and back to the left side of the heart).

systole  The contraction, or period of contraction, of the heart, especially that of the ventricles.

target tissues  Selected tissues to which hormones are directed to act on.

temporal lobe  The portion of the brain that plays an important role in hearing and memory.

temporomandibular joint (TMJ)  The joint where the mandible meets with the temporal bone of the cranium just in front of each ear.

tendons  Specialized tough cords or bands of dense white connective tissue that attaches muscles to bones.

tertiary bronchi  Airway passages in the lungs that are formed from branching of the secondary bronchi.
testes  The male reproductive organs that produce sperm and secrete male hormones; also called testicles.

testicle  A male genital gland that contains specialized cells that produce hormones and sperm.

tetraiodothyronine  One of the two major hormones produced by the thyroid gland; it is essential for normal growth and development in children, as well as regulation of body metabolism.

thalamus  The part of the diencephalon that processes most sensory input and influences mood and general body movements, especially those associated with fear or rage.

thoracic cage  The chest or rib cage.

thoracic duct  One of two great lymph vessels; it empties into the superior vena cava.

thoracic spine  The 12 vertebrae that lie between the cervical vertebrae and the lumbar vertebrae. One pair of ribs is attached to each of the thoracic vertebrae.

thorax  The chest cavity that contains the heart, lungs, esophagus, and great vessels (the aorta and the two venae cavae).

thrombin  An enzyme that causes the conversion of fibrinogen to fibrin, which binds to the platelet plug, forming the final mature clot.

thymus  A triangular-shaped gland located below the sternum in the superior mediastinum; it produces lymphocytes.

thyroglobulin  A protein to which thyroid hormones are bound.

thyroid cartilage  A firm prominence of cartilage that forms the upper part of the larynx; the Adam's apple.

thyroid gland  A large endocrine gland that is located at the base of the neck and produces and excretes hormones that influence growth, development, and metabolism.

thyroid-stimulating hormone (TSH)  Hormone that controls the release of thyroid hormone from the thyroid gland; also called thyrotropin.

thyrotropin  Hormone that controls the release of thyroid hormone from the thyroid gland; also called thyroid-stimulating hormone.

thyroxine-binding globulin  A protein synthesized in the liver that binds to hormones T₃ and T₄.
triiodothyronine  One of the two major hormones produced by the thyroid gland, it is essential for normal growth and development in children, as well as regulation of body metabolism.

trismus  Spasm of the muscles of chewing.

trochlear nerve  The cranial nerve (IV) that innervates the superior oblique muscle of the eyeball, which allows a downward gaze.

true vocal cords  The inferior portion of the vocal cords that vibrate to produce sound.

tunica adventitia  The outer layer of tissue of a blood vessel wall, composed of elastic and fibrous connective tissue.

tunica intima  The smooth, thin, inner lining of a blood vessel.

tunica media  The middle and thickest layer of tissue of a blood vessel wall, composed of elastic tissue and smooth muscle cells that allow the vessel to expand or contract in response to changes in blood pressure and tissue demand.

turbinates  A set of bony convolutions formed by the conchae in the nasopharynx that help to maintain smooth airflow.

ulna  The inner bone of the forearm, on the side opposite the thumb.

ulnar nerve  The nerve in the arm that innervates muscles that flex the wrist and fingers and abduct and adduct the fingers and thumb.

ureter  A small, hollow tube that carries urine from the kidneys to the bladder.

urethra  The canal that conveys urine from the bladder to outside the body.

urinary bladder  A sac behind the pubic symphysis made of smooth muscle that collects and stores urine.

urinary system  The organs that control the discharge of certain waste materials filtered from the blood and excreted as urine.

uvula  A small fleshy mass that hangs from the soft palate.

vagina  A muscular distensible tube that connects the uterus with the vulva (the external female genitalia); also called the birth canal.

vagus nerve  The cranial nerve (X) that provides motor functions to the soft palate, pharynx, and larynx and carries taste bud fibers from the posterior tongue, sensory fibers from the inferior pharynx, larynx, thoracic, and abdominal organs, and parasympathetic fibers to thoracic and abdominal organs.

vasa deferentia (vas deferens)  The spermatic duct of the testicles; also called vas deferens.

vasopressin  A hormone secreted by the posterior pituitary lobe of the pituitary gland, it constricts blood vessels and raises the blood pressure; also called antidiuretic hormone (ADH).

veins  The blood vessels that transport blood back to the heart.

venous sinuses  Spaces between the membranes surrounding the brain that are the primary means of venous drainage from the brain.

ventilation  The process of moving air into and out of the lungs.

ventral  The anterior surface of the body.

ventral root  One of two roots of a spinal nerve that is formed from six to eight rootlets.

ventricle  Lower chamber of the heart; also used to refer to specialized hollow areas in the brain.

vertebrae  The 33 bones that make up the spinal column.

vertebral canal  The bony canal formed by vertebrae that houses and protects the spinal cord.

vertebral column  The spine or primary support structure of the body, which houses the spinal cord and the peripheral nerves.

vestibular folds  The superior portion of the vocal cords. Also called the false vocal cords.

vestibulocochlear nerve  The cranial nerve (VIII) that passes through the internal auditory meatus and transmits information important to the senses of hearing and balance.

visceral layer  The layer of the serous pericardium that lies closely against the heart; also called the epicardium.

visceral pleura  The pleural membrane that covers the lungs.
vital capacity The amount of air moved in and out of the lungs with maximum inspiration and exhalation.
voluntary Consciously controlled, as in skeletal muscle tissue.
voluntary muscle Muscle that is under direct voluntary control of the brain and can be contracted or relaxed at will; skeletal, or striated, muscle.
white blood cells Blood cells that play a role in the body's immune defense mechanisms against infection; also called leukocytes.
xiphoid process The narrow, cartilaginous lower tip of the sternum.

zona fasciculata One of three divisions of the adrenal cortex; it produces corticosteroids.

zona glomerulosa One of three divisions of the adrenal cortex; it produces mineralocorticoids.

zona reticularis One of three divisions of the adrenal cortex; it secretes a few relatively weak male sex hormones, or androgens.

zygomatic arch The bone that extends along the front of the skull below the orbit.
You and your partner are dispatched for a medical emergency. Upon arrival you see an older woman sitting in a chair. She tells you that she has not been feeling well for a few days. Your partner begins to obtain her vital signs.

You ask her to indicate where she is feeling pain. She points to her upper left abdomen, where she has point tenderness. She also tells you that she has pain in her lower back that radiates to either side. As you continue your assessment, you begin to think about what may be wrong. What organs may be involved?

1. The study of the body functions of a living organism to an abnormal state such as a disease is called:
   A. anatomy.
   B. physiology.
   C. pathophysiology.
   D. biology.

2. The human body is made up of trillions of building blocks. These building blocks are the basis for life and are called:
   A. tissues.
   B. organs.
   C. organ systems.
   D. cells.

3. The directional term used when referring to the back of the body is called:
   A. ventral.
   B. dorsal.
   C. superior.
   D. medial.

4. The separation of the extracellular and intracellular area by a selectively permeable membrane helps to maintain:
   A. homeostasis.
   B. equilibrium.
   C. selective permeability.
   D. diffusion.

5. Chemical reactions that take place within the body that provide energy are called:
   A. homeostasis.
   B. metabolism.
   C. xiphoid process.
   D. diffusion.

6. The organs of the left upper quadrant include the:
   A. liver, gallbladder, and parts of the small and large intestine.
   B. stomach, spleen, appendix, and parts of the small and large intestine.
   C. pancreas, spleen, liver, and parts of the small and large intestine.
   D. stomach, spleen, and parts of the small and large intestine.

7. The lower midportion of the pelvic ring where the left and right sides fuse together is called the:
   A. sacrum.
   B. pubic symphysis.
   C. ileum.
   D. ischium.

8. The part of the brain responsible for heart rate, vessel dilation and constriction, swallowing, vomiting, coughing, and sneezing is the:
   A. cerebrum.
   B. medulla.
   C. cerebellum.
   D. pons.

9. The large gland at the base of the neck that consists of two lobes is called the:
   A. isthmus.
   B. pancreas.
   C. pituitary.
   D. thyroid.
10. A thin plasma-like fluid formed from the interstitial or extracellular fluid that bathes the tissues of the body is known as:
   A. hemoglobin.
   B. lymph.
   C. synovial fluid.
   D. blood.

11. The system that includes the organs and structure associated with breathing, gas exchange, and entrance of air into the body is called the:
   A. digestive system.
   B. integumentary system.
   C. respiratory system.
   D. equilibrium system.

12. The organ that detoxifies poisonous substances produced by digestion is called the:
   A. pancreas.
   B. spleen.
   C. stomach.
   D. liver.
**Points to Ponder**

Your agency requires that you attend continuing education sessions each month. Included in each session is a section on anatomy and physiology, which you think is a waste of time. On your last shift, you brought in a patient complaining of severe abdominal pain. Later on that day you saw the emergency department physician and you asked him about your patient’s condition. The doctor told you that she had an obstruction in the ileum. On your way back to your station you tell your partner that the patient you had earlier had some problem with her pelvis. Did you understand what the doctor explained to you? Was he referring to the pelvis or to the small intestine?

**Issues:** Understanding Anatomy and Physiology Terms, Communicating With Health Care Providers